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14. ABSTRACT
In this project, we braided together three strands of research to study how interface design and decision strategies interact to affect adaptive choice behavior in a dynamic decision paradigm. In the first strand are computational models of dynamic decision-making built within a well-recognized cognitive architecture, ACT-R. Our second strand is composed of the decades-plus research efforts that show that people adopt decision-making strategies that tradeoff effectiveness for efficiency. Of particular importance is work showing that the way in which information is presented and how decision aids are constructed may unintentionally influence the decision strategies adopted. The third strand is work from our own lab showing the influence of hard and soft constraints on routine interactive behavior. This work suggests that the cognitive system works locally to optimize non-deliberate choices but that the sum of such locally optimized choices may be far from an optimized global outcome. These strands are braided together in Argus Prime: a simulated task environment of a radar operator's task that was designed to study the interaction between the sometimes conflicting top-down and bottom-up demands.

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Final Report

COMPUTATIONAL COGNITIVE MODELING OF ADAPTIVE CHOICE BEHAVIOR IN A DYNAMIC DECISION PARADIGM

For Period from 15-Feb-2003 to 14-Feb-2006

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1 Objectives

(Original objectives – additional objectives are included below this section).

We propose a program of basic research in the context of a complex, dynamic, decision environment. Our program draws on and integrates ideas, theories, and technologies from various areas of cognitive science. We expect our work to be applied towards a variety of basic research and cognitive engineering objectives.

1.1 Basic Research Objectives

Our core objective is to extent our work on computational modeling of soft constraints to judgment and decision-making tasks. A partial list of research objectives that this would address include the following:

1. Computational models of simple choice tasks have been built (Anderson & Lebiere, 1998). However, building computational models of judgment and decision-making (JDM) tasks would be, at least, an order of magnitude more complex than any choice task currently modeled.
2. A key problem for JDM is what makes a decision difficult (Hastie, 2001). Some information processing demands of different decision strategies have been studied. However, this work has not been embedded in a theory of the control of cognition that integrates central cognitive processes, with shifts in attention, memory retrieval, eye movements, and motor movements. We propose to make progress on this issue by grounding our work in a complete theory of cognition.
3. What are the roles of intuitive versus analytic processes in judgment and decision making (Hastie, 2001)? To what extent are the selection and execution of decision strategies under analytic (top-down or deliberate) control and to what extent are they subject to intuitive (bottom-up or non-deliberate) processes?
4. Is decision making like buying a train ticket or like sailing a boat on a rough sea (Hastie, 2001)? Much decision research assumes that decision strategies are selected once and then executed (i.e., like buying a ticket and then getting on the train). In reality, decision making may be better viewed as a "sequence of linked decisions in a dynamic, temporally extended future" (i.e., sailing a boat). Can a model subject be built that at each step in the decision-making process, bases its next step on its assessment of the current state of the information environment (which changes from step to step). Will the process and outcome of decision making for the model match the process and outcome of human decision making?
5. Support for Soft Constraint theory. Soft Constraint theory emphasizes the role of local as opposed to global least-cost considerations. Local decisions are rational in the classic sense of rationality; however, the sum of hundreds of locally rational (but non-deliberate) decisions may produce behavior that deviates from global assessments of rationality.

1.2 Cognitive Engineering Objectives

Our cognitive engineering objectives flow from the proposed basic research effort. These objectives represent long term themes in our work that we expect the proposed effort to greatly advance.

6. Cognitive engineering of interface design. We expect that our research will lead towards the development of guidelines, model-based approaches, and other tools that can be applied to test the cognitive efficiency of interfaces and the effectiveness of the decision-making strategies that they lead the user to adopt.
7. Cognitive models as users. A long-term goal of our research is the development of model subjects that can be used in usability testing. Use of model subjects will change the nature of usability testing by permitting earlier testing, many more cycles of testing, and a quick determination of the affect of design changes on human error and cognitive workload. The use of model subjects will change, but not eliminate, the role of human subjects in usability testing.
8. Cognitive engineering of decision strategies. Model railroads are easy to build, but building model oceans is difficult. If decision making is more like sailing a boat on a rough ocean than like buying a train ticket, then we need a new approach to designing decision aids than supports the decision

maker during the entire voyage. The current work will help move the design of decision aids in this direction.

1.3 *Additional Objectives:* Workshop on Integrated Models of Cognitive Systems (IMoCS)

The major change to objectives this year was the addition of funds to support the running of a small workshop on Integrated Models of Cognitive Systems (IMoCS).

2 Status of Effort

(Limit to 200 words)

2.1 Workshop on Integrated Models of Cognitive Systems

The Integrated Models of Cognitive System workshop was held March 3-6 in Saratoga Springs, NY. It represented an attempt to bring together communities of researchers who do work related to the control of cognitive systems but from very different perspectives. Papers resulting from the workshop are currently in press with Oxford University Press (OUP).

2.2 Adaptive Choice Behavior in a Dynamic Decision Paradigm

Steady scientific progress has been made on all major objectives. This progress has been well documented in a stream of papers published in peer-reviewed journals and presented at conferences. A major break through has been the development of the soft constraints hypothesis that applies a rational analysis approach to understanding and predicting resource allocation in interactive behavior. This work has led us to better understand the tradeoffs in human cognitive control between local costs and global benefits and how to capture these effects in architectures of cognition. Among other accomplishments, this work has resulted in a major paper accepted for publication in Cognitive Psychology (Fu & Gray, in press), an exploration of the limits of ACT-R's credit assignment mechanism published in the Cognitive System Research journal (Gray, Schoelles, & Sims, 2005), and a major paper that has recently been accepted by a major journal (Gray, Sims, Fu, & Schoelles, 2006).

3 Accomplishments/New Findings

Describe research highlights, their significance to the field, their relationship to the original goals, their relevance to the AF's mission, and their potential applications to AF and civilian technology challenges.

3.1 Tradeoffs Between Interaction-Intensive And Memory-Intensive Microstrategies For Implementing Steps In Decision-Making

The main effort focuses on making the connection between what are normally considered low-level, non-deliberate cognitive processes and higher-order strategic outcomes. Specially, the work as proceeded by posing and attempting to answer three questions regarding the control of the decision-making system.

a. 1st-Order Control: Do small differences in interaction costs lead people to implement the same step in the decision-making process in different ways?
b. 2nd-Order Control: Do these changes in how a step is implemented affect the decision-making strategy that subjects adopt?
c. 3rd-Order Control: Do the strategies adopted as a result of interaction costs affect the outcome of decision-making (i.e., overall performance)?

DMAP-1 and DMAP-2 have yielded important evidence for the 1^{st} and 2^{nd} order control question. Small differences in interaction costs affects the patterns of eye movements used to acquire information and also affects the frequency with which people reacquire information from a given target. In DMAP-1 the low cost of scanning the target-

column for threat values led the *Table* condition to use all of the data to achieve near perfect performance in decision-making. In contrast, the lockout conditions satisficed by using less than 100% of the target data. In contrast, although the two lockout conditions did not differ in the amount of information accessed, the differences in lockout time led each group of subjects to implement the information access step in very different ways. The *0-Lock* group adopted an interaction-intensive procedure that made good use of perceptual–motor operations to minimize memory load. In contrast, the *2-Lock* group adopted a memory-intensive procedure that maximized memory load and minimized lockout time per alternative. (Gray, 2004; Gray & Schoelles, 2003; Gray, Schoelles, & Myers, 2004; Schoelles, Neth, Myers, & Gray, 2006)

The different procedures adopted by the different groups reflect an adaptation of cognition, perception, and action to the cost structure or soft constraints (Gray & Fu, 2004) of the task environment.

3.2 The Soft Constraints Hypothesis: A Rational Analysis Approach to Resource Allocation for Interactive Behavior

Soft constraints hypothesis (SCH) is a rational analysis approach that holds that the mixture of perceptual-motor and cognitive resources allocated for interactive behavior is adjusted based on temporal cost-benefit tradeoffs. Alternative approaches maintain that cognitive resources are in some sense protected or conserved in that greater amounts of perceptual-motor effort will be expended to conserve lesser amounts of cognitive effort. One alternative, the minimum memory hypothesis (MMH), holds that people favor strategies that minimize the use of memory. SCH is compared with MMH across 3 experiments and with predictions of an Ideal Performer Model that uses ACT-R's memory system in a reinforcement learning approach that maximizes expected utility by minimizing time. Model and data support the SCH view of resource allocation; at the under 1000-millisecond level of analysis, mixtures of cognitive and perceptual-motor resources are adjusted based on their cost-benefit tradeoffs for interactive behavior. (Paper describing this work is listed below as, Gray et al., 2006)

3.3 Adapting to the Task Environment: Explorations in Expected Value

Small variations in how a task is designed can lead humans to tradeoff one set of strategies for another. In a paper published this past year in the *Cognitive Systems Research* journal, we discuss our failure to model such tradeoffs in the Blocks World task using ACT-R's default mechanism for selecting the best production among competing productions. ACT-R's selection mechanism, its expected value equation, has had many successes (see, for example, Anderson & Lebiere, 1998) and a recognized strength of this approach is that, across a wide variety of tasks, it tends to produce models that adapt to their task environment about as fast as humans adapt. (This congruence with human behavior is in marked contrast to other popular ways of computing the utility of alternative choices; for example, Reinforcement Learning or most Connectionist learning methods.) We believe that the failure to model the Blocks World task stems from the requirement in ACT-R that all actions must be counted as a binary success or failure. In Blocks World, as well as in many other circumstances, actions can be met with mixed success or partial failure. Working within ACT-R's expected value equation we replaced the binary success/failure judgment with three variations on a scalar one. We then compare the performance of each alternative with ACT-R's default scheme and with the human data. We concluded our paper by discussing the limits and generality of our attempts to replace ACT-R's binary scheme with a scalar credit assignment mechanism.

3.4 Ideal Performer Models, simBorgs, for the Focused Exploration of Cognitive Contributions in Complex Simulated Task Environment

We have continued to develop the notion of simBorgs as an ideal performer model by analogy to the use of the ideal observer analysis (Geisler, 2004; Macmillan & Creelman, 2004) to "determine the optimal performance in a task, given the physical properties of the environment and stimuli" (Geisler, 2004). The ideal observer may be degraded in a systematic fashion "by including, for example, hypothesized sources of internal noise (Barlow 1977), inefficiencies in central decision processes (Barlow 1977; Green & Swets 1966; Pelli 1990), or known anatomical or

physiological factors that would limit performance (Geisler 1989)" (Geisler, 2004). In our case, our simBorgs are being used in the DMAP studies to localize the source of the tradeoffs we observe in human behavior to limitations in either visual search or memory.

The DMAP tasks present the human subjects with a complex task environment that makes demands on cognition, perception, and action. In such an environment it is difficult to disentangle the contribution of one subsystem from that of other key subsystems. The *simulated cyborg* (or *simBorg*) approach provides a principled approach to cognitive modeling, blending computational embodied-cognitive models of interactive behavior with artificial intelligence based components. This combination of high fidelity cognitive modeling (human) and AI (machine) facilitates the development of families of models that allow the modeler to functionally separate components (e.g., memory, vision, etc) at different levels of cognitive fidelity. For example, to determine the importance of visual search for human performance in the DMAP task, we are building a variety of simBorg, called a seeBorg, that optimizes memory but provides a high fidelity model of human visual search. In this example, if a perfect memory seeBorg matches human performance then we would have evidence that human performance in our task is not limited by memory, but by the strategies used in visual search.

We view simBorgs as providing an additional tool to the researcher who is interested in making precise statements about the role of different cognitive subsystems in complex cognition performance. (A paper describing our recent efforts in this has been recently submitted for publication as, Schoelles et al., 2006)

3.5 Computing the Similarity of Sequential Behavior

During this past year, Christopher Myers has continued his award winning research (the Castellan prize for best student paper – see below) on analyze of sequential behavior for both eye movements and mouse movements. Indeed, he has successfully transferred his technology to AFRL/HE Mesa was it was used this summer to compare predicted versus actual sequences of eye movements.

Current technology provides researchers' the capability to collect high-density/high-definition data. However, the potential of such capabilities is diminished without the availability of objective analyses. For example, techniques to objectively compare two complete behavioral routines, two subsections within the same routine, or two subsections between two different routines have been elusive. The capability to objectively compare interactive routines of behavior will enable researchers to study the adoption and evolution of such routines. In work recently accepted for presentation at the HFES2005 conference (see below) Myers' discussed his technique for objectively compare behavioral routines, whether the data are obtained from a human or embodied computational model. This technique offers the promise of solving what Anderson (2002) regarded as the non-determinism problem of modeling behavior at the 100-ms level of behavior. The technique is housed within a software tool for integrating and analyzing fixed-location and movement data collected from eyes and cursors, simultaneously. Recent descriptions of this work have appeared as (Myers, 2005; Myers & Schoelles, 2005).

3.6 *Influencing Saccadic Selectivity: The Effect of and Interplay between Stimulus–Driven and Strategic Factors on Initial Fixations during Visual Search*

Saccadic selectivity refers to the systematic selection of some visual locations rather than others due to one of two sources: stimulus-driven processes or deliberately adopted goal-driven processes. In research inspired by difficulties in understanding human behavior in the DMAP tasks, we manipulate the global configuration of a visual display to study its influence on the initial fixation in a search task. We also manipulate cognitive load. Across three experiments we found a systematic influence of global configuration on saccadic selectivity. In the second experiment we found that performing a secondary task increases the influence of our global configuration on saccadic selectivity. Experiment 3 pushed our paradigm to its limit to reveal adaptive tradeoffs between stimulus–driven and goal–driven processes.

This work has resulted in two conference presentations (Myers, Gray, & Schoelles, 2004a, 2004b) and a masters thesis (Myers, 2004). In the past year, the data has been reanalyzed and further analysis have been performed using

the ProtoMatch system for eye data. A draft of a journal paper currently exists and has been submitted for publication as (Myers & Gray, 2006).

3.7 More is Not Always Better: The Role of Feedback in Stable Suboptimal Performance

Situations that present individuals with a conflict between local and global gains often result in a behavioral pattern known as melioration — a preference for immediate reinforcements over higher, long-term gains. Using a variant of a paradigm by Tunney & Shanks (2002), we explored the potential role of feedback as a means to reduce this bias. We hypothesized that frequent and informative feedback about optimal performance might be the key to enable people to overcome their tendency to meliorate when choices are rewarded probabilistically. Much to our surprise, this intuition turned out to be mistaken. Instead of maximizing, 19 out of 22 participants demonstrated a clear bias towards melioration, regardless of feedback condition. From a human factors perspective, our results suggest that even frequent normative feedback may be insufficient to overcome inefficient choice allocation. We discuss this work and its implications for the theoretical notion of rationality in a paper that was presented at the 2005 conference of the Human Factors and Ergonomics Society (Neth, Sims, & Gray, 2005). This work was inspired by our DMAP studies and represents an effort to understand and predict the circumstances under which human choice behavior will be suboptimal.

4 Personnel Supported

List professional personnel (Faculty, Post-Docs, Graduate Students, etc.) supported by and/or associated with the research effort.

- Wayne D. Gray, PI – Professor of Cognitive Science
- Michael J. Schoelles, co-PI – Research Assistant Professor of Cognitive Science
- Hansjörg Neth – Post-Doctoral Researcher
- Christopher W. Myers – graduate student
- Chris Sims – graduate student
- V. Daniel Veksler – graduate student

5 Publications

List peer-reviewed publications submitted and/or accepted during the 12-month period starting the previous 1 October (or since start for new awards).

All published and in-press papers can be downloaded from:
http://www.rpi.edu/~grayw/pubs/downloadable_pubs.htm

Gray, W. D., Neth, H., & Schoelles, M. J. (in press). The functional task environment. In A. Kramer, A. Kirlik & D. Wiegman (Eds.), *Applied attention*. Mahwah, NJ: Lawrence Erlbaum Associates.

Gray, W. D. (in press). Integrating cognition: The challenge to building unified architectures of cognition posed by type 1, 2, and 3 theories of cognition. In W. D. Gray (Ed.), *Integrated models of cognitive systems*. New York: Oxford University Press.

Gray, W. D. (Ed.). (in press). *Integrated models of cognitive systems*. New York: Oxford University Press.

Gray, W. D. (in press). The emerging rapprochement between cognitive and ecological analyses. In A. Kirlik (Ed.), *Adaptation in human-technology interaction*. New York: Oxford University Press.

Gray, W. D., Sims, C. R., Fu, W.-T., & Schoelles, M. J. (2006). The soft constraints hypothesis: A rational analysis approach to resource allocation for interactive behavior. *Psychological Review, in press.*

Gray, W. D. O., & Myers, C. W. (2005). From models to methods to models: Tools and techniques for using, developing, and analyzing cognitive human performance models. In *49th Annual Conference of the Human Factors and Ergonomics Society*. Santa Monica, CA: Human Factors and Ergonomics Society.

Gray, W. D., Schoelles, M. J., & Sims, C. R. (2005). Cognitive metrics profiling. In *49th Annual Conference of the Human Factors and Ergonomics Society*. Santa Monica, CA: Human Factors and Ergonomics Society.

Fu, W.-T., & Gray, W. D. (in press). Suboptimal tradeoffs in information seeking. *Cognitive Psychology*.

Myers, C. W., & Gray, W. D. (2006). Influencing saccadic selectivity: The effect of and interplay between stimulus-driven and strategic factors on initial fixations during visual search. *Manuscript submitted for publication.*

Myers, C. W. (2005). Computing the similarity of sequential behavior. In *49th Annual Conference of the Human Factors and Ergonomics Society*. Santa Monica, CA: Human Factors and Ergonomics Society.

Myers, C. W. (2005). Toward a method of objectively determining scanpath similarity, *5th annual meeting of the Vision Sciences Society*. Saratoga, FL.

Myers, C. W., & Schoelles, M. J. (2005). ProtoMatch: A tool for analyzing high-density, sequential, behavioral protocols. *Behavior Research Methods, 37*(2), 256-270.

Neth, H., Myers, C. W., & Gray, W. D. (submitted for publication). *Memory Modulates Visual Search: Interactions of External and Internal Representations.* Paper presented at the Vision Sciences Conference, Sarasota, FL.

Neth, H., Sims, C. R., & Gray, W. D. (submitted for publication). *Melioration Dominates Maximization: Stable Suboptimal Performance Despite Global Feedback.*

Neth, H., Sims, C., & Gray, W. D. (2005). More is not always better: The role of feedback in stable suboptimal performance. In *49th Annual Conference of the Human Factors and Ergonomics Society*. Santa Monica, CA: Human Factors and Ergonomics Society.

Neth, H., Gray, W. D., & Myers, C. W. (2005). Memory models of visual search: Searching in-the-head vs. in-the-world? *Journal of Vision, 5*(8), 417.

6 Interactions/Transitions:

a. Participation/presentations at meetings, conferences, seminars, etc.

Gray, W. D. (2005, Oct 25). *Soft Constraints versus the Minimum Memory Hypothesis: Metering Tradeoffs between Interaction-Intensive and Memory-Intensive Operations.* Paper presented at the Invited Talk Texas Tech, Lubbock, TX.

Gray, W. D. (2005, May 24). *Bridging the human-computer information gap: Understanding soft constraints in interactive behavior.* Paper presented at the Human Systems Integration, Naval Undersea Warfare Center Division, Newport, RI.

Gray, W. D. (2005, April). *Near-Optimal Tradeoffs between Interaction-Intensive and Memory-Intensive Strategies: Towards a Theory of Soft Constraints in Interactive Behavior.* Paper presented at the Invited Talk Vassar College, Vassar College, Ploughkeepsie, NY.

Gray, W. D., & Schoelles, M. J. (2005, July 15-18). *Profile Before Optimizing A Cognitive Metrics Approach to Workload Analysis.* Paper presented at the ACT-R Workshop, Treite, Italy.

Gray, W. D. (2005, February). *Near-Optimal Tradeoffs between Interaction-Intensive and Memory-Intensive Strategies Towards a Theory of Soft Constraints in Interactive Behavior.* Paper presented at the Invited Talk Psychology Department, University of Albany, Albany NY.

Gray, W. D. (2005, January). *Advancing Towards a Rapprochement between Cognitive and Ecological Analyses: Embodied Cognition, Architectures of Cognition, and Soft Constraints.* Paper presented at the Workshop on Human Performance Modeling, Queensland, Australia.

Gray, W. D., & Schoelles, M. J. (2005, April 19). *Near-Optimal Tradeoffs between Interaction-Intensive and Memory-Intensive Strategies Towards a Theory of Soft Constraints in Interactive Behavior.* Paper presented at the Air Force Office of Scientific Research: Cognitive Program Review, St. Augustine, FL.

Gray, W. D. (2005, June 08). *Bridging the human-computer information gap by cognitively engineering next generation workstations for information workers.* Paper presented at the Air Force Research Laboratory, Rome NY.

Gray, W. D. O., & Myers, C. W. (2005). From models to methods to models: Tools and techniques for using, developing, and analyzing cognitive human performance models. In *49th Annual Conference of the Human Factors and Ergonomics Society.* Santa Monica, CA: Human Factors and Ergonomics Society.

Gray, W. D., Schoelles, M. J., & Sims, C. R. (2005). Cognitive metrics profiling. In *49th Annual Conference of the Human Factors and Ergonomics Society.* Santa Monica, CA: Human Factors and Ergonomics Society.

Neth, H., Sims, C. R., & Gray, W. D. (2005). Melioration despite more information: The role of feedback frequency in stable suboptimal performance. *Proceedings of the 49th annual meeting of the Human Factors and Ergonomics Society*, pp. 357–361.

Neth, H., Sims, C., & Gray, W. D. (2005). More is not always better: The role of feedback in stable suboptimal performance. In *49th Annual Conference of the Human Factors and Ergonomics Society.* Santa Monica, CA: Human Factors and Ergonomics Society.

Neth, H., Gray, W. D., & Myers, C. W. (2005). Memory Models of Visual Search – Searching in-the-head vs. in-the-world? *5th annual meeting of the Vision Sciences Society.* Saratoga, FL.

Sims, C., & Gray, W. D. (2005, July 15-18). *Interactive behavior at the sticking point: The curious persistence of apparent inefficient interactive routines.* Paper presented at the ACT-R Workshop, Treite, Italy.

b. Consultative and advisory functions to other laboratories and agencies, especially Air Force and other DoD laboratories. Provide factual information about the subject matter, institutions, locations, dates, and name(s) of principal individuals involved.

March 3-6. Workshop on Integrated Models of Cognitive Systems. Saratoga Springs, NY. AFOSR sponsored workshop organized by Wayne D. Gray. Featured 30 of the best researchers in the world on the subject of control of cognition. Attendees from the government included: Robert Sorkin (AFOSR); Paul Bello (AFRL/IF); Kevin Gluck (AFRL/HE); Astrid Schmidt-Nielson (ONR); Susan Chipman (ONR).

February 17-18, 2005: Computational cognitive modeling meeting sponsored by Dr. Kevin Gluck at AFRL/HE Mesa, AZ.

AFRL/HE: Jerry Ball, Glenn Gunzelmann, Don Lyon, Michael Krusmark, Goeffrey Barbier, Chad Tossell, Heather Pringle, LtC Stuart Roger; Kevin Gluck

AFOSR: Gen Haddad

AFRL/IF: Paul Bello

Non-Govt: Nancy Cooke (ASU); Ron Chong (GMU); Brad Best (MAaD); Frank Ritter (PSU); and Wray (SoarTech).

June 2005: Traveled to AFRL/IF Rome, NY to present talk (listed above) entitled: *Bridging the human-computer information gap by cognitively engineering next generation workstations for information workers.*

c. Transitions. Describe cases where knowledge resulting from your effort is used, or will be used, in a technology application. Transitions can be to entities in the DoD, other federal agencies, or industry. Briefly list the enabling research, the laboratory or company, and an individual in that organization who made use of your research.

A graduate student on this project, Mr. Christopher W. Myers, spent summer of 2005 as a student intern at AFRL/HE Mesa. He worked directly with Drs. Kevin Gluck and Glenn Gunzelmann. One of his roles in the lab was to bring the ProtoMatch software that Mr. Myers developed for analyzing scan paths into AFRL/HE. Mr. Myers won the Castellan Award at the annual meeting of the Society for Computers in Psychology (SCiP) in November 2004 for best student paper for his ProtoMatch system.

Some of our work on Dynamic Decision-making that has been funded by AFOSR is beginning to find its way into simulated task environments for Intelligence Analysts in our ARDA-funded work in the Novel Intelligence from Massive Data program. (We are subcontractors to contract # MDA-904-03-C-0408 to Booz Allen Hamilton from the Advanced Research and Development
Activity, Novel Intelligence from Massive Data Program.) The particular work concerns our use of simBorgs. The contact would be Heather McMonagle the COTR (AJhamcm@fggm.osis.gov).

7 New discoveries, inventions, or patent disclosures

(If none, report None.

None

8 Honors/Awards

List honors and awards received during the grant/contract period. List lifetime achievement honors such as Nobel Prize, honorary doctorates, and society fellowships prior to this effort.

Associate Editor of the Cognitive Science journal
Castellan Award for best student paper awarded to Christopher W. Myers in November 2004 by the Society for Computers in Psychology for his work in developing the ProtoMatch system for scanpath analysis.
Chair of the Cognitive Science Society (2004-2006 term as Chair-elect, Chair, and Past-Chair)
Chair and co-founder of the Human Performance Modeling Technical Group of the Human Factors and Ergonomics Society
Associate Editor of the Cognitive Systems Research journal
Associate Editor of the Human Factors journal
Editorial Board member of the Cognitive Science journal

9 Papers Cited in this Report

Anderson, J. R., & Lebiere, C. (Eds.). (1998). *Atomic components of thought.* Hillsdale, NJ: Lawrence Erlbaum Associates.

Fu, W.-T., & Gray, W. D. (in press). Suboptimal tradeoffs in information seeking. *Cognitive Psychology.*

Geisler, W. S. (2004). Ideal Observer analysis. In L. M. Chalupa & J. S. Werner (Eds.), *The visual neurosciences* (pp. 825-837). Boston: MIT Press.

Gray, W. D. (2004, March). *Explorations in dynamic decision making.* Paper presented at the Air Force Office of Scientific Research Workshop for the Cognitive/Decision Making Program, Phoenix, AZ.

Gray, W. D., & Fu, W.-T. (2004). Soft constraints in interactive behavior: The case of ignoring perfect knowledge in-the-world for imperfect knowledge in-the-head. *Cognitive Science, 28*(3), 359-382.

Gray, W. D., & Schoelles, M. J. (2003). The nature and timing of interruptions in a complex, cognitive task: Empirical data and computational cognitive models. In R. Alterman & D. Kirsch (Eds.), *25th Annual Conference of the Cognitive Science Society.* Austin, TX: Cognitive Science Society.

Gray, W. D., Schoelles, M. J., & Myers, C. W. (2004). Strategy constancy amidst implementation differences: Interaction-intensive versus memory-intensive adaptations to information access in decision-making. In K. D. Forbus, D. Gentner & T. Regier (Eds.), *26th Annual Meeting of the Cognitive Science Society, CogSci2004* (pp. 482-487). Hillsdale, NJ: Lawrence Erlbaum Publisher.

Gray, W. D., Schoelles, M. J., & Sims, C. R. (2005). Adapting to the task environment: Explorations in expected value. *Cognitive Systems Research, 6*(1), 27-40.

Gray, W. D., Sims, C. R., Fu, W.-T., & Schoelles, M. J. (2006). The soft constraints hypothesis: A rational analysis approach to resource allocation for interactive behavior. *Psychological Review, in press.*

Hastie, R. (2001). Problems for judgment and decision making. *Annual Review of Psychology, 52*, 653–683.

Macmillan, N. A., & Creelman, C. D. (2004). *Detection theory: A user's guide.* Mahwah, NJ: Lawrence Erlbaum Associates.

Myers, C. W. (2004). *The effects of global stimulus configuration and cognitive load on saccadic selectivity.* Rensselaer Polytechnic Institute, Troy, NY.

Myers, C. W. (2005). Computing the similarity of sequential behavior. In *49th Annual Conference of the Human Factors and Ergonomics Society*. Santa Monica, CA: Human Factors and Ergonomics Society.

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